

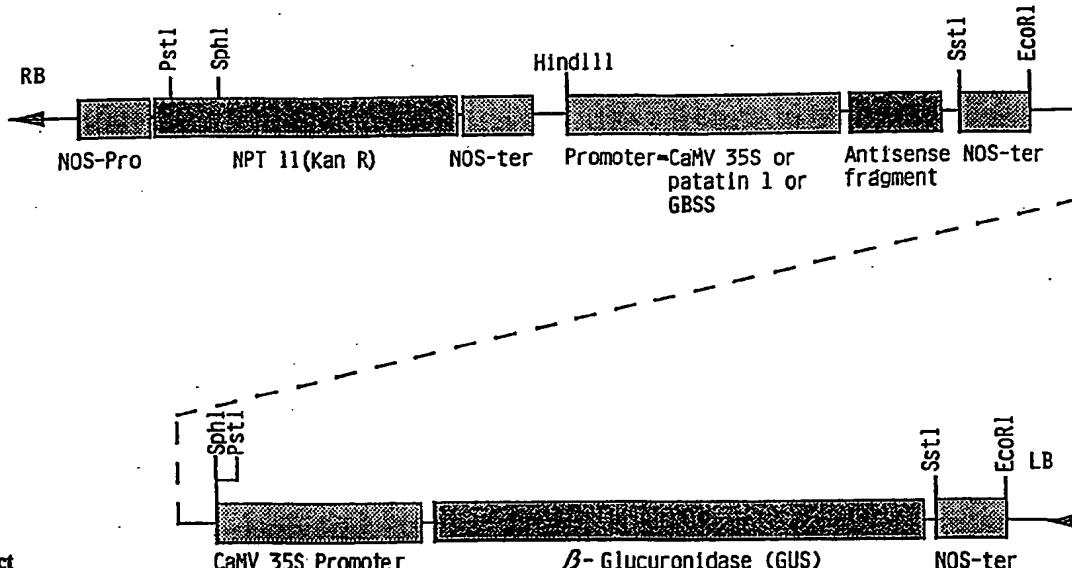


## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : <b>C12N 15/56, 9/44, A01H 5/00</b>		A1	(11) International Publication Number: <b>WO 92/11375</b> (43) International Publication Date: <b>9 July 1992 (09.07.92)</b>
(21) International Application Number: <b>PCT/SE91/00891</b>			(74) Agent: AWAPATENT AB; Box 5117, S-200 71 Malmö (SE).
(22) International Filing Date: <b>20 December 1991 (20.12.91)</b>			(81) Designated States: AT, AT (European patent), AU, BB, BE (European patent), BF (OAPI patent), BG, BJ (OAPI patent), BR, CA, CF (OAPI patent), CG (OAPI patent), CH, CH (European patent), CI (OAPI patent), CM (OAPI patent), DE, DE (European patent), DK, DK (European patent), ES, ES (European patent), FI, FR (European patent), GA (OAPI patent), GB, GB (European patent), GN (OAPI patent), GR (European patent), HU, IT (European patent), JP, KP, KR, LK, LU, LU (European patent), MC (European patent), MG, ML (OAPI patent), MR (OAPI patent), MW, NL, NL (European patent), NO, PL, RO, SD, SE, SE (European patent), SN (OAPI patent), SU <sup>+</sup> , TD (OAPI patent), TG (OAPI patent), US.
(30) Priority data: <b>9004095-7</b> 21 December 1990 (21.12.90) SE			
(71) Applicant (for all designated States except US): <b>AMYLO-GENE HB [SE/SE]; c/o Svalöf AB, S-268 81 Svalöf (SE).</b>			
(72) Inventors; and			Published
(75) Inventors/Applicants (for US only) : <b>HOFVANDER, Per [SE/SE]; Doppinggränd 8, S-230 11 Falsterbo (SE). PERSSON, Per, T. [SE/SE]; Travgatan 9, S-291 65 Kristianstad (SE). TALLBERG, Anneli [SE/SE]; Drapavägen 69, S-223 74 Lund (SE). WIKSTRÖM, Olle [SE/SE]; Wasagatan 1, S-291 53 Kristianstad (SE).</b>			<i>With international search report. In English translation (filed in Swedish).</i>

## (54) Title: GENETICALLY ENGINEERED MODIFICATION OF POTATO TO FORM AMYLOSE-TYPE STARCH

Antisense constructs. Outside RB and LB as pBIN19



## (57) Abstract

Genetically engineered modification of potato for suppressing formation of amylopectin-type starch is described. The invention describes an antisense construct for inhibiting, to a varying extent, the expression of the gene coding for formation of branching enzyme (BE gene) in potato, said antisense construct comprising a tuber-specific promoter, transcription start and the first exon of the BE gene, inserted in the antisense direction. Also cells, plants, tubers, microtubers and seeds of potato comprising said antisense construct are described. Finally, amylose-type starch, both native and derivatised, derived from the potato that is modified in a genetically engineered manner, as well as a method of suppressing amylopectin formation in potato are described.

**+ DESIGNATIONS OF "SU"**

Any designation of "SU" has effect in the Russian Federation. It is not yet known whether any such designation has effect in other States of the former Soviet Union.

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	ES	Spain	MG	Madagascar
AU	Australia	FI	Finland	ML	Mali
BB	Barbados	FR	France	MN	Mongolia
BE	Belgium	GA	Gabon	MR	Mauritania
BF	Burkina Faso	GB	United Kingdom	MW	Malawi
BG	Bulgaria	CN	Guinea	NL	Netherlands
BJ	Benin	GR	Greece	NO	Norway
BR	Brazil	HU	Hungary	PL	Poland
CA	Canada	IT	Italy	RO	Romania
CF	Central African Republic	JP	Japan	SD	Sudan
CG	Congo	KP	Democratic People's Republic of Korea	SE	Sweden
CH	Switzerland	KR	Republic of Korea	SN	Senegal
CI	Côte d'Ivoire	LI	Liechtenstein	SU+	Soviet Union
CM	Cameroon	LK	Sri Lanka	TD	Chad
CS	Czechoslovakia	LU	Luxembourg	TC	Togo
DE	Germany	MC	Monaco	US	United States of America

GENETICALLY ENGINEERED MODIFICATION OF POTATO  
TO FORM AMYLOSE-TYPE STARCH

The present invention relates to genetically engineered modification of potato, resulting in the formation of an increasing amount of amylose-type starch as compared to amylopectin-type starch in the potato. The genetically engineered modification implies the insertion of a gene fragment into potato, said gene fragment comprising transcription start and a part of the gene coding for the formation of branching enzyme (BE gene) in potato, inserted in the antisense direction, together with a tuber-specific promoter.

Background of the Invention

Starch in various forms is of great import in the food and paper industry. In future, starch will also be a great potential for producing polymers which are degradable in nature, e.g. for use as packing material. Many different starch products are known which are produced by derivatisation of native starch originating from, inter alia, maize and potato. Starch from potato and maize, respectively, is competing in most market areas.

In the potato tuber, starch is the greatest part of the solid matter. About 1/4 to 1/5 of the starch in potato is amylose, while the remainder of the starch is amylopectin. These two components of the starch have different fields of application, and therefore the possibility of producing either pure amylose or pure amylopectin is most interesting. The two starch components can be produced from common starch, which requires a number of process steps and, consequently, is expensive and complicated.

It has now proved that by genetic engineering it is possible to modify potato so that the proportion between the two starch components amylose and amylopectin changes in the actual tubers. As a result, a starch quality is obtained which can compete in the areas where potato starch is normally not used today. Starch from such potato

which is modified in a genetically engineered manner has great potential as a food additive, since it has not been subjected to any chemical modification process.

#### Starch Synthesis

5        The synthesis of starch and the regulation thereof are presently being studied with great interest, both on the level of basic research and for industrial application. Although much is known about the assistance of certain enzymes in the transformation of saccharose into 10 starch, the biosynthesis of starch has not yet been elucidated. By making researches above all into maize, it has, however, been possible to elucidate part of the ways of synthesis and the enzymes participating in these reactions. The most important starch-synthesising enzymes for 15 producing the starch granules are starch synthase and branching enzyme. In maize, three forms of starch synthase have so far been demonstrated and studied, two of which are soluble and one is insolubly associated with the starch granules. Also branching enzyme in maize consists 20 of three forms which are probably coded by three different genes.

#### Branching Enzyme in Different Plant Species

The starch granules contain a mixture of linear and branched molecules which form the starch components amylose and amylopectin. Amylopectin is produced by interaction between starch synthase and branching enzyme, 25 alpha-1,4-glucan; alpha-1,4-glucan-6-glucosyl transferase (EC 2.4.1.18). Branching enzyme (BE) hydrolyses alpha-1,4 bonds and synthetises alpha-1,6 bonds (Mac 30 Donald & Preiss, 1985; Preiss, 1988).

Endosperm of normal maize contains three forms of BE protein, designated BE I, BE IIa and BE IIb. The mutation amylose extender (ae) inhibits the activity of the enzyme BE IIb, which results in a reduced content of amylopectin 35 and a corresponding increase of the amylose content. ae endosperm thus has a different proportion of amylose to

amylopectin than normal maize, viz. 65:35 instead of 25:75 (De Vries Kuranda, 1987).

Although the similarities between the three enzyme forms are great, each of them has properties in its primary structure which make them unique. The genes for each enzyme form have not been identified so far, but by isolation of cDNA clones for each BE form, each gene can in all probability be characterised.

In normal pea, two forms of branching enzyme (BE) have been identified. A mutation in r locus, which results in a creased pea, affects the activity of BE, thereby inhibiting one enzyme form. This results in a modified composition of the starch with 30% amylopectin and 70% amylose, as compared to the reversed proportion in round normal pea (Smith, 1988).

Branching enzyme (BE) in potato is a monomer protein, i.e. it is a single enzyme form. The molecular weight of potato BE varies between 79 and 103 kD, depending on the purifying process used. There are indications that potato BE should consist of several forms, but presumably several forms are degradation products from the actual protein (Vos-Scheperkeuter, 1989; Blennow & Johansson, 1990).

Peptide sequencing of three BE forms, separated by electrophoresis, has such great homology between the enzyme forms that these are assumed to have the same origin. Serological tests support this assumption, since antisera from the three enzyme forms cross-react with each other.

#### Inhibition of Branching Enzyme

By inhibiting one of the forms of branching enzyme in maize and pea, the composition of the starch changes so that the content of amylose increases strongly at the sacrifice of the amylopectin production.

In potato, a natural genotype with an increased content of amylose has not been found so far. However, it is possible to reduce the content of BE to a varying extent, which results in the starch in the potato tuber having

increased contents of amylose as compared to common potato.

The reduction of the formation of enzyme can be accomplished in several ways, e.g. by:

- 5 - mutagen treatment which results in a modification of the gene sequence coding for the formation of the enzyme
- incorporation of a transposon in the gene sequence coding for the enzyme
- genetically engineered modification so that the expression of the gene coding for the enzyme is modified by 10 so-called antisense gene inhibition.

Fig. 1 illustrates a specific suppression of normal gene expression in that a complementary antisense nucleotide is allowed to hybridise with mRNA for a target gene. 15 The antisense nucleotide thus is antisense RNA which is transcribed in vivo from a "reversed" gene sequence (Izant, 1989).

By using the antisense technique, various gene functions in plants have been inhibited. The antisense construct for chalcone synthase, polygalacturonase and phosphinotricin acetyltransferase has been used to inhibit the corresponding enzyme in the plant species petunia, tomato and tobacco (Van der Krol et al, 1990; Sheehy et al, 1988; Cornelissen, 1989).

25 The object of the invention is to provide a varyingly increased amylose production in potato tuber by using antisense gene inhibition.

#### Summary of the Invention

According to the invention the function of the BE gene and, thus, the amylopectin production in potato are inhibited to a varying extent by using new antisense constructs. The antisense constructs according to the invention comprise a tuber-specific promoter, transcription start and the first exon of the gene coding for formation of branching enzyme (BE gene) in potato, inserted 30 35 in the antisense direction.

The invention also comprises a gene coding for formation of branching enzyme in potato, the so-called BE gene.

The invention further comprises vectors including the antisense constructs according to the invention.

5 In further aspects, the invention comprises cells, plants, tubers, microtubers and seeds, whose genome contains the antisense constructs according to the invention.

10 In still further aspects, the invention comprises amylose-type starch, both native and derivatised.

Finally, the invention comprises a method of suppressing formation of amylopectin-type starch in potato, whereby the potato tubers form a varyingly increased amount of amylose-type starch.

15 The invention will now be described in more detail with reference to the accompanying figures in which

Fig. 1 illustrates the principle of the antisense gene inhibition, and

20 Fig. 2 shows antisense constructs according to the invention (according to Bevan, 1984).

Moreover, the sequence of a tuber-specific promoter is shown in SEQ ID No. 1.

#### Isolation of Genomic BE Gene in Potato

Based on a known peptide sequence from the BE gene in potato, two synthetic oligo nucleotides overlapping one another are produced. The oligo nucleotides (produced at the Institute for Cell Biology, Uppsala, Sweden, at the applicant's request) are used for identification of cDNA clones from a cDNA library in lambda gt 11 (produced on 25 the applicant's behalf by Clontech, USA). The cDNA clones are used for isolation of the genomic BE gene from a genomic library in EMBL 3 (produced on the applicant's behalf by Clontech, USA).

#### Antisense Constructs

35 A varying increase of the amylose content in potato tubers is desired, and therefore different types of antisense genes are constructed which more or less inhibit the

expression of the BE gene in vivo. One starts from the isolated genomic BE gene, whereby the antisense constructs comprise parts of the BE gene corresponding to sequences in the region of the promoter, transcription start and the 5 first exon.

In order to obtain both variation of the amylose content and tissue specificity, i.e. the production of amylopectin should be reduced in the potato tuber only, different tuber-specific promoters are coupled to the antisense 10 gene. In addition to the own BE promoter of the tuber, the following promoters are used in different combinations: 35S CaMV, patatin I (obtained from Dr M. Bevan, England) and the potato GBSS promoter.

Isolation and characterisation of the potato GBSS 15 gene is described in the simultaneously filed patent application having the title "Genetically engineered modification of potato to form amylopectin-type starch" by the same applicant, and its nucleotide sequence is shown in SEQ ID No. 1. The GBSS promoter is included in the potato 20 gene coding for formation of granule-bound starch synthase. This is the enzyme which mainly is responsible for the formation of amylose in potato.

The binary Ti plasmides pBI 121 and pBI 101 (supplied by Clontech, USA) are used as a basis for all gene structures 25 (Fig. 2), which means that NPT-II and the GUS gene are selection markers. The GUS gene is the gene which codes for beta-glucuronidase.

#### Transformation

The antisense constructs are transferred to bacteria, 30 suitably by the "freeze-thawing" method (An et al, 1988). The transfer of the recombinant bacterium to potato tissue occurs by incubation of the potato tissue with the recombinant bacterium in a suitable medium after some sort of damage has been inflicted upon the potato tissue. During 35 the incubation, T-DNA from the bacterium enters the DNA of the host plant. After the incubation, the bacteria are killed and the potato tissue is transferred to a solid

medium for callus induction and is incubated for growth of callus.

After passing through further suitable media, sprouts are formed which are cut away from the potato tissue.

5 As a first check that the antisense constructs have been transferred to the potato tissue, this is analysed regarding the presence of the used marker.

Further checks for testing the expression of the antisense constructs and the transfer thereof to the potato genome are carried out by e.g. southern and northern hybridisation (Maniatis et al (1982)). The number of 10 copies of the antisense construct which has been transferred is determined by southern hybridisation.

The testing of the expression on protein level is 15 suitably carried out on microtubers induced in vitro on the transformed sprouts, thus permitting the testing to be performed as quickly as possible.

#### Characterisation of the Starch

The composition of the starch in microtubers is identical with that of ordinary potato tubers, and therefore 20 the effect of the antisense constructs on the amylopectin production is examined in microtubers. The proportion of amylose to amylopectin can be determined by a spectrophotometric method (e.g. according to Hovenkamp-Hermelink 25 et al, 1988).

#### Extraction of Amylose from Amylose Potato

Amylose is extracted from the so-called amylose potato (potato in which the formation of amylopectin has been suppressed to a varying extent by inserting the 30 antisense constructs according to the invention) in a known manner.

#### Derivatisation of Amylose

Depending on the final use of the amylose, its physical and chemical qualities can be modified by derivatisation. By derivatisation is here meant chemical, physical and enzymatic treatment and combinations thereof 35 (modified starches).

The chemical derivatisation, i.e. chemical modification of the amylose, can be carried out in different ways, for example by oxidation, acid hydrolysis, dextrinisation, different forms of etherification, such as cationisation, 5 hydroxy propylation and hydroxy ethylation, different forms of esterification, for example by vinyl acetate, acetic anhydride, or by monophosphatising, diphosphatising and octenyl succination, and combinations thereof.

Physical modification of the amylose can be effected 10 by e.g. cylinder-drying or extrusion.

In enzymatic derivatisation, degradation (reduction of the viscosity) and chemical modification of the amylose are effected by means of existing enzymatic systems.

The derivatisation is effected at different temperatures, according to the desired end product. The ordinary 15 range of temperature which is used is 20-45°C, but temperatures up to 180°C are possible.

The invention will be described in more detail in the following Examples.

20 Example 1

Production of microtubers with inserted antisense constructs according to the invention

The antisense constructs (see Fig. 2) are transferred to *Agrobacterium tumefaciens* LBA 4404 by the "freeze-thawing" method (An et al, 1988). The transfer to potato tissue is carried out according to a modified protocol from 25 Rocha-Sosa et al (1989).

Leaf discs from potato plants cultured in vitro are incubated in darkness on a liquid MS-medium (Murashige & 30 Skoog; 1962) with 3% saccharose and 0.5% MES together with 100 µl of a suspension of recombinant *Agrobacterium* per 10 ml medium for two days. After these two days the bacteria are killed. The leaf discs are transferred to a solid medium for callus induction and incubated for 4-6 weeks, 35 depending on the growth of callus. The solid medium is composed as follows:

MS + 3% saccharose

2 mg/l zeatin riboside

0.02 mg/l "NAA"

0.02 mg/l "GA<sub>3</sub>"

5 500 mg/l "Claforan"

50 mg/l kanamycin

0.25% "Gellan"

Subsequently the leaf discs are transferred to a medium having a different composition of hormones, comprising:

MS + 3% saccharose

5 mg/l "NAA"

0.1 mg/l "BAP"

500 mg/l "Claforan"

15 50 mg/l kanamycin

0.25% "Gellan".

The leaf discs are stored on this medium for about 4 weeks, whereupon they are transferred to a medium in which the "Claforan" concentration has been reduced to 20 250 mg/l. If required, the leaf discs are then moved to a fresh medium every 4 or 5 weeks. After the formation of sprouts, these are cut away from the leaf discs and transferred to an identical medium.

The condition that the antisense construct has been 25 transferred to the leaf discs is first checked by analysing the presence of the GUS gene. Leaf extracts from the regenerated sprouts are analysed in respect of glucuronidase activity by means of the substrates described by Jefferson et al (1987). The acitivity is demonstrated by 30 visual assessment.

Further tests of the expression of the antisense constructs and the transfer thereof to the potato genome are carried out by southern and northern hybridisation according to Maniatis et al (1982). The number of copies 35 of the antisense constructs that has been transferred is determined by southern hybridisation.

10

When it has been established that the antisense constructs have been transferred to and expressed in the potato genome, the testing of the expression on protein level begins. The testing is carried out on microtubers 5 which have been induced in vitro on the transformed sprouts, thereby avoiding the necessity of waiting for the development of a complete potato plant with potato tubers.

Stem pieces of the potato sprouts are cut off at the nodes and placed on a modified MS medium. There they form 10 microtubers after 2-3 weeks in incubation in darkness at 19°C (Bourque et al, 1987). The medium is composed as follows:

MS + 6% saccharose  
2.5 mg/l kinetin  
15 2.5 mg/l "Gellan"

The effect of the antisense constructs on the function of the BE gene in respect of the activity of the BE protein is analysed by means of electrophoresis on polyacrylamide gel (Hovenkamp-Hermelink et al, 1987). Starch 20 is extracted from the microtubers and analysed regarding the presence of the BE protein.

The composition of the starch, i.e. the proportion of amylose to amylopectin, is determined by a spectrophotometric method according to Hovenkamp-Hermelink et al 25 (1988), the content of each starch component being determined on the basis of a standard graph.

#### Example 2

##### Extraction of amylose from amylose potato.

Potato whose main starch component is amylose, below 30 called amylose potato, modified in a genetically engineered manner according to the invention, is grated, thereby releasing the starch from the cell walls.

The cell walls (fibres) are separated from fruit juice and starch in centrifugal screens (centrisiler). The 35 fruit juice is separated from the starch in two steps, viz. first in hydrocyclones and subsequently in specially designed band-type vacuum filters.

## 11

Then a finishing refining is carried out in hydro-cyclones in which the remainder of the fruit juice and fibres are separated.

The product is dried in two steps, first by predrying 5 on a vacuum filter and subsequently by final drying in a hot-air current.

Example 3

## Chemical derivatisation of amylose

Amylose is sludged in water to a concentration of 10 20-50%. The pH is adjusted to 10.0-12.0 and a quaternary ammonium compound is added in such a quantity that the end product obtains a degree of substitution of 0.004-0.2. The reaction temperature is set at 20-45°C. When the reaction is completed, the pH is adjusted to 4-8, whereupon the 15 product is washed and dried. In this manner the cationic starch derivative 2-hydroxy-3-trimethyl ammonium propyl ether is obtained.

Example 4

## Chemical derivatisation of amylose

Amylose is sludged in water to a water content of 20 10-25% by weight. The pH is adjusted to 10.0-12.0, and a quaternary ammonium compound is added in such a quantity that the end product obtains a degree of substitution of 0.004-0.2. The reaction temperature is set at 20-45°C. 25 When the reaction is completed, the pH is adjusted to 4-8. The end product is 2-hydroxy-3-trimethyl ammonium propyl ether.

Example 5

## Chemical derivatisation of amylose

Amylose is sludged in water to a concentration of 30 20-50% by weight. The pH is adjusted to 5.0-12.0, and sodium hypochlorite is added so that the end product obtains the desired viscosity. The reaction temperature is set at 20-45°C. When the reaction is completed, the pH is 35 adjusted to 4-8, whereupon the end product is washed and dried. In this manner, oxidised starch is obtained.

12

Example 6Physical derivatisation of amylose

Amylose is sludged in water to a concentration of 20-50% by weight, whereupon the sludge is applied to 5 a heated cylinder where it is dried to a film.

Example 7Chemical and physical derivatisation of amylose

Amylose is treated according to the process described in one of Examples 3-5 for chemical modification and 10 is then further treated according to Example 6 for physical derivatisation.

15

20

25

30

35

References:

- Blennow, A. & Johansson, G., 1990. Phytochemistry (in press)
- De Vries Kuranda, K., 1987. Immunological characterization of normal and amylose-extender alleles of *Zea mays* L.: Effects on the starch branching enzymes. Thesis for a doctorate. The Pennsylvania State University.
- Mac Donald, F. D. & Preiss, J., 1985. Plant Physiol 78:849-852.
- Preiss, J., 1988. In Biochemistry of Plants: 14 (Carbohydrates) Ed. J. Preiss, Academic Press; 181-254.
- Smith, A., 1988. Plant 175:270-279.
- Vos-Scheperskeuter, G. H., de Wit, J. G., Ponstein, A. S., Feenstra, W. J. & Witholt, B., 1989. Plant Physiol 90:75-84.
- Cornelissen, M., 1989. Nucleic Acids Res 17(18):7203-7209.
- Izant, J. G., 1989. Cell Motility and Cytoskeleton 14:81-91.
- Sheehy, R. E., Kramer, M., Hiatt, W. R., 1988. Proc. Natl. Acad. Sci., USA, 85(23):8805-8809.
- Van der Krol, A. R., Mur, L. A., de Lange, P., Gerats, A. G. M., Mol, J. N. M. & Stuitje, A. R., 1990. Mol. Gen. Genet. 220:204-212.
- An, G., Ebert, P. R., Mitra, A. & Ha, S. B., 1988. Plant Mol Biol. Manual A3:1-19.
- Murashige, T. & Skoog, F., 1962. Physiol. Plant 15:473-497.
- Rocha-Sosa, M., Sonnewald, U., Frommer, W., Stratmann, M., Shell, J. & Willmitzer, L., 1989. EMBO J. 8(1):23-29.
- Jefferson, R. A., Kavanagh, R. A. & Bevan, M. W., 1987. EMBO J. 6:3901-3907.
- Maniatis, T., Fritsch, E. F. & Sambrook, J., 1982. Molecular Cloning. A Laboratory Handbook. Cold Spring Harbor Laboratory Press, Cold Spring Harbor.

14

- Bourque, J. E., Miller, J. C. & Park, W. D., 1987. In *Vitro Cellular & Development Biology* 23(5):381-386.
- Hovenkamp-Hermelink, J. H. M., de Vries, J. N., Adamse, P., Jacobsen, E., Witholt, B. & Feenstra, W. J., 1988.
- 5 Potato Research 31:241-246.
- Modified starches: Properties and use, D. B. Wurzburg.
- Bevan, M. W., 1984. *Nucleic Acids Res.* 12:8711-8721.

10

15

20

25

30

35

15

SEQ ID No. 1

Sequenced molecule: genomic DNA

Name: Promoter for the GBSS gene from potato

Length of sequence: 629 bp

AACCATCCTT	CCTTTAGCA	GTGTATCAAT	TTTGTAAATAG	AACCATGCAT	50
ACTCAATCTT	AATACTAAAA	TGCAACTTAA	TATAGGCTAA	ACCAAGTAAA	100
GTAATGTATT	CAACCTTGT	AATTGTGCAT	TCATAATTAG	ATCTTGTTG	150
TCGTAAAAAA	TTAGAAAATA	TATTTACAGT	AATTGGAAT	ACAAAGCTAA	200
GGGGGAAGTA	ACTAATATTTC	TAGTGGAGGG	AGGGACCAGT	ACCAAGTACCT	250
AGATATTATT	TTAATTACT	ATAATAATAA	TTTAATTAAC	ACGAGACATA	300
GGAATGTCAA	GTGGTAGCGT	AGGAGGGAGT	TGGTTTAGTT	TTTGTAGATAC	350
TAGGAGACAG	AACCAGGACGG	CCCATTGCAA	GGCCAGTTG	AAGTCCAGCC	400
GTGAATCAAC	AAAGAGAGGG	CCCATTATAC	TGTGATGAG	CATTTCCCTA	450
TAATACAGTG	TCCACAGTTG	CCTTCTGCTA	AGGGATAGCC	ACCCGCTATT	500
CTCTTGACAC	GTGTCAGTGA	AACCTGCTAC	AAATAAGGCA	GGCAACCTCCT	550
CATTCTCACT	CACTCACTCA	CACAGCTCAA	CAAGTGGTAA	CTTTTACTCA	600
TCTCCTCCAA	TTATTCTGA	TTTCATGCA			629

## CLAIMS

1. Antisense construct for inhibition, to a varying extent, of the expression of the gene coding for formation of branching enzyme (the BE gene) in potato, said antisense construct comprising a tuber-specific promoter, transcription start and the first exon of the BE gene, inserted in the antisense direction.  
5
- 10 2. Antisense construct as claimed in claim 1, further comprising a selection marker.
- 15 3. Antisense construct as claimed in claim 1 or 2, wherein the promoter is a promoter for the gene in potato, which codes for granule-bound starch synthase (GBSS) and which essentially has the nucleotide sequence stated in SEQ ID No. 1.
- 20 4. Antisense construct as claimed in claim 1 or 2, wherein the promoter is selected among the CaMV 35S promoter and the patatin I promoter.
- 25 5. Gene coding for formation of branching enzyme in potato.
6. Vector comprising an antisense construct as claimed in one or more of claims 1-4.
7. Cell of potato plant, whose genome comprises an antisense construct as claimed in one or more of claims 1-4.  
25
8. Potato plant whose genome comprises an antisense construct as claimed in one or more of claims 1-4.
9. Potato tubers whose genome comprises an antisense construct as claimed in one or more of claims 1-4.  
30
10. Seeds from potato plant, whose genome comprises an antisense construct as claimed in one or more of claims 1-4.
11. Microtubers of potato, whose genome comprises an antisense construct as claimed in one or more of claims 1-4.  
35

17

12. Amylose-type native starch, characterised in that it has been obtained from potato which has been modified in a genetically engineered manner for suppressing formation of amylopectin-type starch.

5 13. Derivatised amylose-type starch, characterised in that it is amylose-type starch extracted from potato which has been modified in a genetically engineered manner for suppressing formation of amylopectin-type starch, said amylose-type starch subsequently being 10 derivatised in a chemical, physical and/or enzymatic manner.

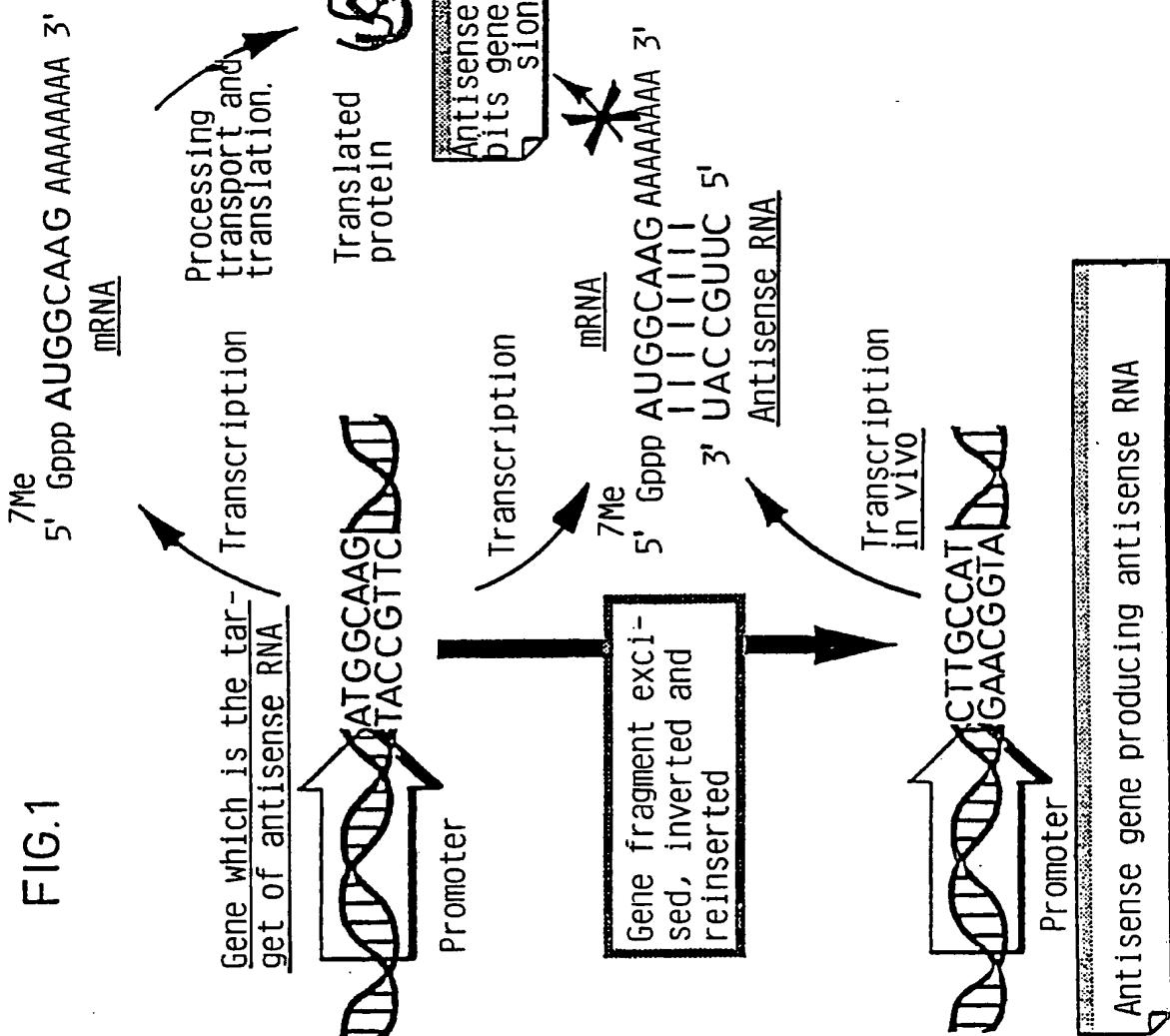
14. Method of suppressing formation of amylopectin-type starch in potato, characterised by genetically engineered modification of the potato by 15 introducing into the genome of the potato tissue an anti-sense construct, comprising a tuber-specific promoter, transcription start and the first exon of the gene coding for formation of branching enzyme (BE gene) in potato, said exon being inserted in the antisense direction.

20

25

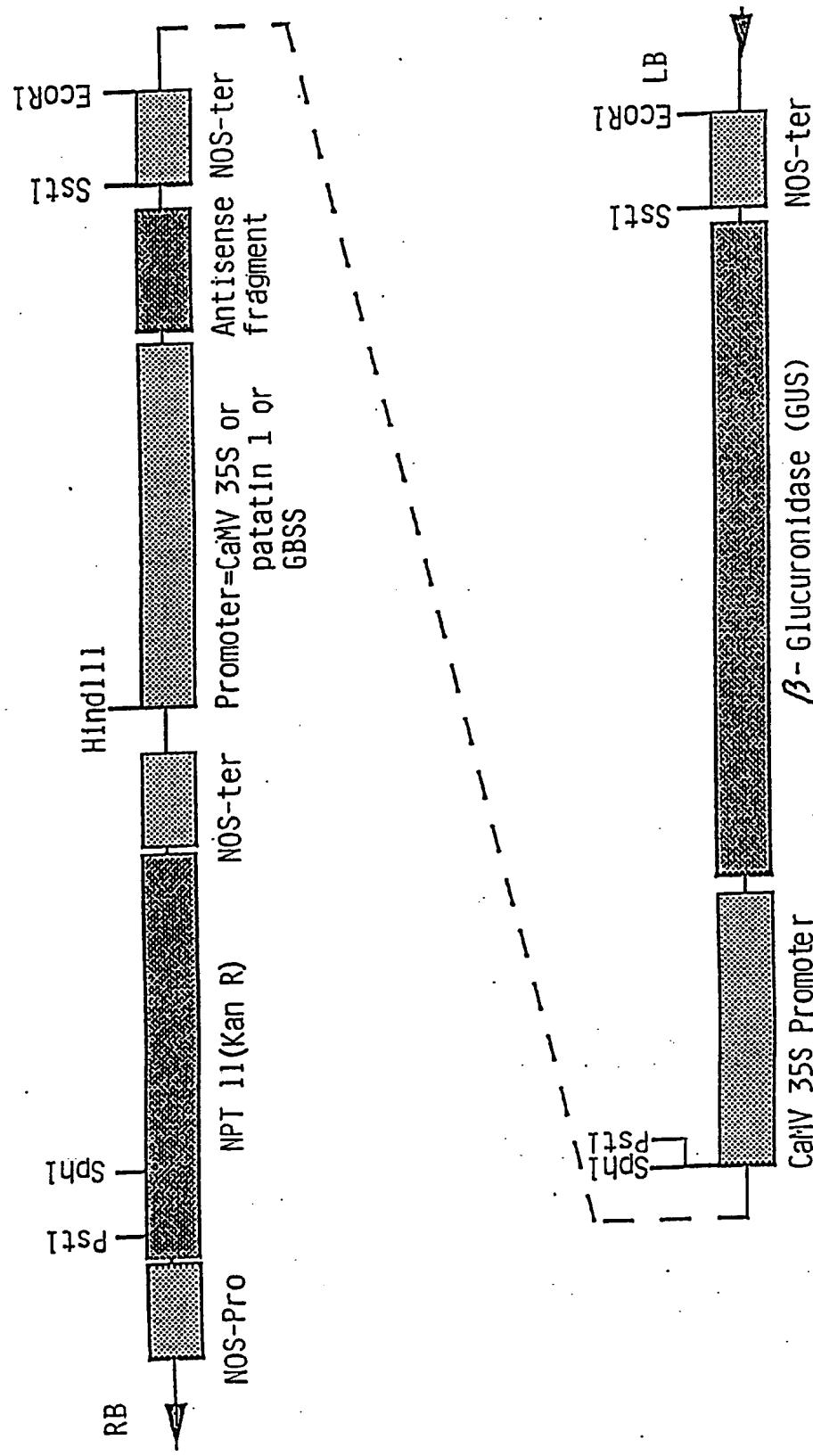
30

35



2/2

FIG.2 Antisense constructs. Outside RB and LB as pBIN19



# INTERNATIONAL SEARCH REPORT

International Application No PCT/SE 91/00891

## I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)<sup>6</sup>

According to International Patent Classification (IPC) or to both National Classification and IPC  
IPC5: C 12 N 15/56, 9/44, A 01 H 5/00

## II. FIELDS SEARCHED

Minimum Documentation Searched<sup>7</sup>

Classification System	Classification Symbols
IPC5	C 12 N; A 01 H

Documentation Searched other than Minimum Documentation  
to the Extent that such Documents are Included in Fields Searched<sup>8</sup>

SE,DK,FI,NO classes as above

## III. DOCUMENTS CONSIDERED TO BE RELEVANT<sup>9</sup>

Category <sup>10</sup>	Citation of Document <sup>11</sup> with indication, where appropriate, of the relevant passages <sup>12</sup>	Relevant to Claim No. <sup>13</sup>
A	EP, A2, 0368506 (IMPERIAL CHEMICAL INDUSTRIES PLC) 16 May 1990, see especially claim 14 --	1-14
A	EP, A2, 0335451 (VERENIGING VOOR CHRISTELIJK WETENSCHAPPELIJK ONDERWIJS) 4 October 1989, see the whole document --	1-14
P,A	PHYTOCHEMISTRY, Vol. 30, No. 2, 1991 Andreas Blennow et al: "Isolation of a Q-enzyme with M 103000 from potato tubers", cited in the application --	1-14
A	PLANT PHYSIOL., Vol. 90, 1989 Greetje H. Vos-Schepenkeuter et al: "Immunological comparison of the starch branching enzymes from potato tubers and maize kernels", see page 75 - page 84 cited in the application --	1-14

\* Special categories of cited documents: <sup>10</sup>

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance, the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance, the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

## IV. CERTIFICATION

Date of the Actual Completion of the International Search

30th March 1992

Date of Mailing of this International Search Report

1992-04-01

International Searching Authority

SWEDISH PATENT OFFICE

Signature of Authorized Officer

  
Mikael G:son Bergstrand

**ANNEX TO THE INTERNATIONAL SEARCH REPORT  
ON INTERNATIONAL PATENT APPLICATION NO.PCT/SE 91/00891**

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.  
The members are as contained in the Swedish Patent Office EDP file on 28/02/92  
The Swedish Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date		Patent family member(s)	Publication date
EP-A2- 0368506	90-05-16		AU-D- JP-A- 2273177	90-08-16 90-11-07
EP-A2- 0335451	89-10-04		JP-A- NL-A- 2016985 8800756	90-01-19 89-10-16